$|V_{ub}|$ from the Spectrum of $B \to \pi e \nu$

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I discuss the results for $|V_{ub}|f_+(0)$ and $|V_{ub}|$ obtained from the spectrum of $B \to \pi e\nu$ and the form factor $f_+(q^2)$ from QCD sum rules on the light-cone and unquenched lattice calculations; the shape of $f_+(q^2)$ is fixed from experimental data.

The determination of $|V_{ub}|$ from $B \to \pi\ell\nu$ requires a theoretical calculation of the hadronic matrix element

$$\begin{aligned}\langle \pi(p_\pi)|\bar{u}\gamma_\mu b|B(p_\pi+q)\rangle &= \\ &= \left(2p_{\pi\mu}+q_\mu-q_\mu\,\frac{m_B^2-m_\pi^2}{q^2}\right) f_+(q^2) \\ &\quad + \frac{m_B^2-m_\pi^2}{q^2}\, q_\mu\, f_0(q^2)\,, \end{aligned} \quad (1)$$

where q_μ is the momentum of the lepton pair, with $0 \approx m_\ell^2 \leq q^2 \leq (m_B - m_\pi)^2 = 26.4\,\mathrm{GeV}^2$. f_+ is the dominant form factor, whereas f_0 enters only at order m_ℓ^2 and can be neglected for $\ell = e,\mu$. The spectrum of $B \to \pi\ell\nu$ in q^2 is then given by

$$\frac{d\Gamma}{dq^2}\,(\bar{B}^0 \to \pi^+\ell^-\bar{\nu}_\ell) = \frac{G_F^2|V_{ub}|^2}{192\pi^3 m_B^3}\,\lambda^{3/2}(q^2)|f_+(q^2)|^2\,, \quad (2)$$

where $\lambda(q^2) = (m_B^2+m_\pi^2-q^2)^2 - 4m_B^2 m_\pi^2$ is the phase-space factor. The calculation of f_+ has been the subject of numerous papers; the current state-of-the-art methods are unquenched lattice simulations [1, 2] and QCD sum rules on the light-cone (LCSRs) [3, 4]. A particular challenge for any theoretical calculation is the prediction of the *shape* of $f_+(q^2)$ for all physical q^2: LCSRs work best for small q^2; lattice calculations, on the other hand, are to date most reliable for large q^2. Hence, until very recently, the prediction of the $B \to \pi\ell\nu$ decay rate necessarily involved an extrapolation of the form factor, either to large or to small q^2. If, on the other hand, the q^2 spectrum were known from experiment, the shape of f_+ could be constrained, allowing an extension of the LCSR and lattice predictions beyond their region of validity. A first study of the impact of the measurement, in 2005, of the q^2 spectrum in 5 bins in q^2 by the BaBar collaboration [5] on the shape of f_+ was presented in Ref. [6]. The situation has improved dramatically in 2006 with the publication of high-precision data of the q^2 spectrum [7], with 12 bins in q^2 and full statistical and systematic error correlation matrices. These data allow one to fit the form factor to various parametrisations and determine the value of $|V_{ub}|f_+(0)$ [8]. As it turns out, the results from all but the simplest parametrisation agree up to tiny differences which suggests that the resulting value of $|V_{ub}|f_+(0)$ is *truly model-independent*. In these proceedings we report the results for $|V_{ub}|f_+(0)$ and $|V_{ub}|$, obtained in Ref. [7, 8].

There are four parametrisations of f_+ which are frequently used in the literature. All of them include the essential feature that f_+ has a pole at $q^2 = m_{B^*}^2$; as $B^*(1^-)$ is a narrow resonance with $m_{B^*} = 5.325\,\mathrm{GeV} < m_B + m_\pi$, it is expected to have a distinctive impact on the form factor. The parametrisations are:

(i) Becirevic/Kaidalov (BK) [9]:

$$f_+(q^2) = \frac{f_+(0)}{(1-q^2/m_{B^*}^2)\,(1-\alpha_{\mathrm{BK}}\,q^2/m_B^2)}\,, \quad (3)$$

where α_{BK} determines the shape of f_+ and $f_+(0)$ the normalisation;

(ii) Ball/Zwicky (BZ) [4]:

$$\begin{aligned} f_+(q^2) &= f_+(0)\left(\frac{1}{1-q^2/m_{B^*}^2}\right. \\ &\quad \left. + \frac{rq^2/m_{B^*}^2}{(1-q^2/m_{B^*}^2)\,(1-\alpha_{\mathrm{BZ}}\,q^2/m_B^2)}\right), \end{aligned} \quad (4)$$

with the two shape parameters α_{BZ}, r and the normalisation $f_+(0)$; BK is a variant of BZ with $\alpha_{\mathrm{BK}} := \alpha_{\mathrm{BZ}} = r$;

(iii) the AFHNV parametrisation of Ref. [10], based on an $(n+1)$-subtracted Omnes respresentation of f_+:

$$f_+(q^2) \overset{n\geqq 1}{=} \frac{1}{m_{B^*}^2-q^2}\prod_{i=0}^{n}\left[f_+(q_i)^2(m_{B^*}^2-q_i^2)\right]^{\alpha_i(q^2)} \quad (5)$$

$$\text{with} \quad \alpha_i(q^2) = \prod_{j=0,j\neq i}^{n}\frac{q^2-s_j}{s_i-s_j}\,; \quad (6)$$

the shape parameters are $f_+(q_i^2)/f_+(q_0^2)$ with $q^2_{0,\dots n}$ the subtraction points;

(iv) the BGL parametrisation based on the analyticity of f_+ [11]:

$$f_+(q^2) = \frac{1}{P(t)\phi(q^2,q_0^2)}\sum_{k=0}^{\infty} a_k(q_0^2)[z(q^2,q_0^2)]^k\,, \quad (7)$$

$$z(q^2,q_0^2) = \frac{\{m_+^2-q^2\}^{1/2}-\{m_+^2-q_0^2\}^{1/2}}{\{m_+^2-q^2\}^{1/2}+\{m_+^2-q_0^2\}^{1/2}} \quad (8)$$

with $m_+ = m_B + m_\pi$ and $\phi(q^2, q_0^2)$ as given in [11]. The "Blaschke" factor $P(q^2) = z(q^2, m_{B^*}^2)$ accounts for the B^* pole. The expansion parameters a_k are constrained by unitarity to fulfill $\sum_k a_k^2 \leq 1$. q_0^2 is a free parameter that can be chosen to attain the tightest possible bounds. The series in (7) provides a systematic expansion in the small parameter z, which for practical purposes has to be truncated at order $k_{\rm max}$. The shape parameters are given by $\{a_k\}$. We minimize χ^2 in $\{a_k\}$ for two choices of q_0^2:

(a) $q_0^2 = (m_B + m_\pi)(\sqrt{m_B} - \sqrt{m_\pi})^2 = 20.062\,{\rm GeV}^2$, which minimizes the possible values of z, $|z| < 0.28$, and hence also minimizes the truncation error of the series in (7) across all q^2; the minimum χ^2 is reached for $k_{\rm max} = 2$;

(b) $q_0^2 = 0\,{\rm GeV}^2$ with $z(0,0) = 0$ and $z(q^2_{\rm max}, 0) = -0.52$, which minimizes the truncation error for small and moderate q^2 where the data are most constraining; the minimum χ^2 is reached for $k_{\rm max} = 3$.

The advantage of BK and BZ is that they are both intuitive and simple; BGL, on the other hand, offers a systematic expansion whose accuracy can be adapted to that of the data to be fitted, so we choose it as our default parametrisation.

We determine the best-fit parameters for all four parametrisations from a minimum-χ^2 analysis. In Tab. I we give the results for $|V_{ub}|f_+(0)$ obtained from fitting the various parametrisations to the BaBar data for the normalised partial branching fractions in 12 bins of q^2: $q^2 \in \{[0,2],[2,4],[4,6],[6,8],[8,10],[10,12],[12,14],[14,16],[16,18],[18,20],[20,22],[22,26.4]\}\,{\rm GeV}^2$; the absolute normalisation is given by the HFAG average of the semileptonic branching ratio, $\mathcal{B}(\bar{B}^0 \to \pi^+\ell^-\bar{\nu}_\ell) = (1.37 \pm 0.06({\rm stat}) \pm 0.07({\rm syst})) \times 10^{-4}$ [12]. It is evident that good values of $\chi^2_{\rm min}$ are obtained for all parametrisations. Our result is

$$|V_{ub}|f_+(0) = (9.1 \pm 0.6({\rm shape}) \pm 0.3({\rm BR})) \times 10^{-4} \quad (9)$$

from BGLa which we choose as default parametrisation. We would like to stress that this result is *completely model-independent*, and also independent of the value of $|V_{ub}|$; it relies solely on the experimental data for $B \to \pi\ell\nu$ from BaBar for the spectrum and the HFAG average of the branching ratio. The BaBar collaboration finds [7] $|V_{ub}|f_+(0) = (9.6 \pm 0.3({\rm stat}) \pm 0.2({\rm syst})) \times 10^{-4}$, using the larger value of the branching ratio $\mathcal{B}(B \to \pi e\nu) = (1.46 \pm 0.07 \pm 0.08) \times 10^{-4}$, while [10] quotes $|V_{ub}|f_+(0) = (8.8 \pm 0.8) \times 10^{-4}$, based on a fit to all available data from BaBar, Belle, CLEO and form factor predictions from both light-cone sum rules and lattice calculations.

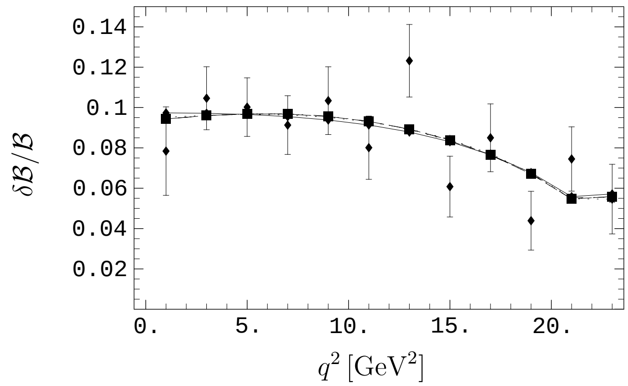

Figure 1: Experimental data for the normalised branching ratio $\delta\mathcal{B}/\mathcal{B}$ per q^2 bin, $\sum \delta\mathcal{B}/\mathcal{B} = 1$, and best fits. The lines are the best-fit results for the five different parametrisations listed in Tab. I. The increase in the last bin is due to the fact that it is wider than the others ($4.4\,{\rm GeV}^2$ vs. $2\,{\rm GeV}^2$).

In Fig. 1 we show the best-fit curves for all parametrisations together with the experimental data and error bars. All fit curves basically coincide except for the BK parametrisation which has a slightly worse $\chi^2_{\rm min}$. In Fig. 2 we show the best-fit form factors themselves. The curve in the left panel is an overlay of all five parametrisations; noticeable differences occur only for large q^2, which is due to the fact that these points are phase-space suppressed in the spectrum and hence cannot be fitted with high accuracy. In the right panel we graphically enhance the differences between the best fits by normalising all parametrisations to our preferred choice BGLa; for $q^2 < 25\,{\rm GeV}^2$, all best-fit form factors agree within 2%.

As mentioned above, theoretical predictions for f_+ are available from lattice calculations and LCSRs. The LCSR calculation [4] includes twist-2 and -3 contributions to $O(\alpha_s)$ accuracy and twist-4 contributions at tree-level. The lattice calculations [1, 2] are unquenched with $N_f = 2 + 1$ dynamical flavours, i.e. mass-degenerate u and d quarks and a heavier s quark. The obvious questions are (a) whether these predictions of $f_+(q^2)$ are compatible with the experimentally determined shape of the form factor and (b) what the resulting value of $|V_{ub}|$ is. In order to answer these questions, we follow two different procedures. We first fit the lattice and LCSR form factors to the BK parametrisation and extract $|V_{ub}|$, for lattice, from $\mathcal{B}(B \to \pi\ell\nu)_{q^2 \geq 16\,{\rm GeV}^2}$, and, for LCSRs, from $\mathcal{B}(B \to \pi\ell\nu)_{q^2 \leq 16\,{\rm GeV}^2}$; the cuts in q^2 are imposed in order to minimise any uncertainty from extrapolating in q^2. The results are shown in the BK column of Tab. II. Equipped with the experimental information on the form factor shape, i.e. the BGLa parametrisation of Tab. I, we also follow a different procedure and perform a fit of the theoretical predictions to this shape, with the normalisation $f_+(0)$ as

	$\lvert V_{ub}\rvert f_+(0)$	Remarks
BK	$(9.3 \pm 0.3 \pm 0.3) \times 10^{-4}$	$\chi^2_{\rm min} = 8.74/11\,$dof $\alpha_{\rm BK} = 0.53 \pm 0.06$
BZ	$(9.1 \pm 0.5 \pm 0.3) \times 10^{-4}$	$\chi^2_{\rm min} = 8.66/10\,$dof $\alpha_{\rm BZ} = 0.40^{+0.15}_{-0.22}$, $r = 0.64^{+0.14}_{-0.13}$
BGLa	$(9.1 \pm 0.6 \pm 0.3) \times 10^{-4}$	$\chi^2_{\rm min} = 8.64/10\,$dof $q_0^2 = 20.062\,{\rm GeV}^2$ $\theta_1 = 1.12^{+0.03}_{-0.04}$, $\theta_2 = 4.45 \pm 0.06$
BGLb	$(9.1 \pm 0.6 \pm 0.3) \times 10^{-4}$	$\chi^2_{\rm min} = 8.64/9\,$dof $q_0^2 = 0\,{\rm GeV}^2$ $\theta_1 = 1.41^{+0.02}_{-0.03}$, $\theta_2 = 3.97 \pm 0.10$, $\theta_3 = 5.11^{+0.67}_{-0.39}$
AFHNV	$(9.1 \pm 0.3 \pm 0.3) \times 10^{-4}$	$\chi^2_{\rm min} = 8.64/8\,$dof $f_+(q^2_{\rm max} \cdot \{1/4, 2/4, 3/4, 4/4\})/f_+(0)$ $= \{1.54 \pm 0.07, 2.56 \pm 0.11, 5.4 \pm 0.4, 26 \pm 11\}$

Table I Model-independent results for $|V_{ub}|f_+(0)$ using the BaBar data for the spectrum [7] and the HFAG average for the total branching ratio [12]. The first error comes from the uncertainties of the parameters determining the shape of f_+; these parameters are given in the right column; full definitions can be found in Ref. [8]. The second error comes from the uncertainty of the branching ratio.

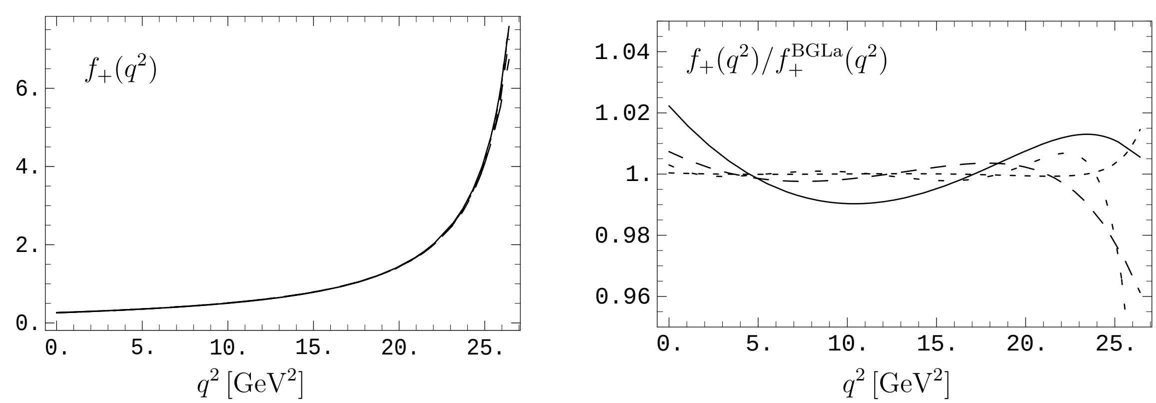

Figure 2: Left panel: best-fit form factors f_+ as a function of q^2. The line is an overlay of all five parametrisations. Right panel: best-fit form factors normalised to BGLa. Solid line: BK, long dashes: BZ, short dashes: BGLb, short dashes with long spaces: AFHNV.

fit parameter. The corresponding results are shown in the right column. Comparing the errors for $|V_{ub}|$ in both columns, it is evident that the main impact of the experimentally fixed shape, i.e. using the BGLa parametrisation of f_+, is a reduction of both theory and experimental errors; this is due to the fact that, once the shape is fixed, $|V_{ub}|$ can be determined from the full branching ratio with only 3% experimental uncertainty, whereas the partical branching fractions in the BK column induce 4% and 6% uncertainty, respectively, for $|V_{ub}|$; the theory error gets reduced because the theoretical uncertainties of f_+ predicted for various q^2 are still rather large, which implies theory uncertainties on the shape parameter α_{BK}, which are larger than those of the experimentally fixed shape parameters.

What is the conclusion to be drawn from these results? Let us compare with $|V_{ub}|$ from inclusive determinations. HFAG gives results obtained using dressed-gluon exponentiation (DGE) [14] and the shape-function formalism (BLNP) [15]:

$$\begin{aligned} |V_{ub}|^{\rm HFAG}_{\rm incl,DGE} &= (4.46 \pm 0.20 \pm 0.20) \times 10^{-3}\,, \\ |V_{ub}|^{\rm HFAG}_{\rm incl,BLNP} &= (4.49 \pm 0.19 \pm 0.27) \times 10^{-3}\,, \qquad (10) \end{aligned}$$

where the first error is experimental (statistical and systematic) and the second external (theoretical and parameter uncertainties). Both results are in perfect agreement. Note that, at this conference, Neubert has quoted a lower value, $|V_{ub}| = (4.10 \pm 0.30({\rm exp}) \pm 0.29({\rm th})) \times 10^{-3}$ [16], based on the subclass of "best"

	BK	BGLa
LCSR	$f_+(0) = 0.26 \pm 0.03\,, \quad \alpha_{\rm BK} = 0.63^{+0.18}_{-0.21}$	$f_+(0) = 0.26 \pm 0.03$
Ref. [4]	$\vert V_{ub}\vert = (3.5 \pm 0.6 \pm 0.1) \times 10^{-4}$	$\vert V_{ub}\vert = (3.5 \pm 0.4 \pm 0.1) \times 10^{-4}$
	$\vert V_{ub}\vert f_+(0) = (9.0^{+0.7}_{-0.6} \pm 0.4) \times 10^{-4}$	
exp. input	$\mathcal{B}(B \to \pi\ell\nu)_{q^2 \leq 16\,{\rm GeV}^2}$	$\mathcal{B}(B \to \pi\ell\nu)$ and BGLa
	$= (0.95 \pm 0.07) \times 10^{-4}$	parameters from Tab. I
HPQCD	$f_+(0) = 0.21 \pm 0.03\,, \quad \alpha_{\rm BK} = 0.56^{+0.08}_{-0.11}$	$f_+(0) = 0.21 \pm 0.03$
Ref. [2]	$\vert V_{ub}\vert = (4.3 \pm 0.7 \pm 0.3) \times 10^{-4}$	$\vert V_{ub}\vert = (4.3 \pm 0.5 \pm 0.1) \times 10^{-4}$
	$\vert V_{ub}\vert f_+(0) = (8.9^{+1.2}_{-0.9} \pm 0.4) \times 10^{-4}$	
exp. input	$\mathcal{B}(B \to \pi\ell\nu)_{q^2 \geq 16\,{\rm GeV}^2}$	$\mathcal{B}(B \to \pi\ell\nu)$ and BGLa
	$= (0.35 \pm 0.04) \times 10^{-4}$	parameters from Tab. I
FNAL	$f_+(0) = 0.23 \pm 0.03\,, \quad \alpha_{\rm BK} = 0.63^{+0.07}_{-0.10}$	$f_+(0) = 0.25 \pm 0.03$
Ref. [1]	$\vert V_{ub}\vert = (3.6 \pm 0.6 \pm 0.2) \times 10^{-4}$	$\vert V_{ub}\vert = (3.7 \pm 0.4 \pm 0.1) \times 10^{-4}$
	$\vert V_{ub}\vert f_+(0) = (8.2^{+1.0}_{-0.8} \pm 0.3) \times 10^{-4}$	
exp. input	$\mathcal{B}(B \to \pi\ell\nu)_{q^2 \geq 16\,{\rm GeV}^2}$	$\mathcal{B}(B \to \pi\ell\nu)$ and BGLa
	$= (0.35 \pm 0.04) \times 10^{-4}$	parameters from Tab. I

Table II $|V_{ub}|$ and $|V_{ub}|f_+(0)$ from various theoretical methods. The column labelled BK gives the results obtained from a fit of the form factor to the BK parametrisation, and the column labelled BGLa those from a fit of $f_+(0)$ to the best-fit BGLa parametrisation from Tab. I. The first uncertainty comes from the shape parameters, the second from the experimental branching ratios; the latter are taken from HFAG [12].

determinations (with highest efficiency and best theoretical control). At the same time, $|V_{ub}|$ can also be determined in a more indirect way, based on global fits of the unitarity triangle (UT), using only input from various CP violating observables which are sensitive to the angles of the UT. Following the UTfit collaboration, we call the corresponding fit of UT parameters UTangles. Both the UTfit [17] and the CKMfitter collaboration [18, 19] find

$$|V_{ub}|^{\rm UTfit,CKMfitter}_{\rm UTangles} = (3.50 \pm 0.18) \times 10^{-3}\,. \qquad (11)$$

The discrepancy between (10) and (11) starts to become significant. One interpretation of this result is that there is new physics (NP) in B_d mixing which impacts the value of $\sin 2\beta$ from $b \to ccs$ transitions, the angle measurement with the smallest uncertainty. The value of $|V_{ub}|$ in (10) implies

$$\beta|_{|V_{ub}|^{\rm HFAG}_{\rm incl}} = (26.9 \pm 2.0)^\circ \;\leftrightarrow\; \sin 2\beta = 0.81 \pm 0.04\,, \qquad (12)$$

using the recent Belle result $\gamma = (53 \pm 20)^\circ$ from the Dalitz-plot analysis of the tree-level process $B^+ \to D^{(*)}K^{(*)+}$ [20].[1] This value disagrees by more than 2σ with the HFAG average for β from $b \to ccs$ transitions, $\beta = (21.2 \pm 1.0)^\circ$ ($\sin 2\beta = 0.675 \pm 0.026$). The difference of these two results indicates the possible presence of a NP phase in B_d mixing, $\phi_d^{\rm NP} \approx -10^\circ$. This interpretation of the experimental situation is in line with that of Ref. [23]. An alternative interpretation is that there is actually no or no significant NP in the mixing phase of B_d mixing, but that the uncertainties in either UTangles or inclusive $b \to u\ell\nu$ transitions (experimental and theoretical) or both are underestimated and that (10) and (11) actually do agree. The main conclusion from this discussion is that both LCSR and FNAL predictions for f_+ support the UTangles value for $|V_{ub}|$, and differ at the 2σ level from the inclusive $|V_{ub}|$, whereas HPQCD supports the inclusive result. Using the experimentally fixed shape of f_+ in the analysis instead of fitting it to the theoretical input points reduces both the theoretical and experimental uncertainty of the extracted $|V_{ub}|$.

To summarize, we have presented a truly model-independent determination of the quantity $|V_{ub}|f_+(0)$ from the experimental data for the spectrum of $B \to \pi\ell\nu$ in the invariant lepton mass provided by the BaBar collaboration [7]; our result is given in (9). We have found that the BZ, BGL and AFHNV parametrisations of the form factor yield, to within 2% accuracy, the same results for $q^2 < 25\,{\rm GeV}^2$. We then have used the best-fit BGLa shape of f_+ to determine $|V_{ub}|$ using three different theoretical predictions for f_+, QCD sum rules on the light-cone [4], and the lattice results of the HPQCD [2] and FNAL collaborations [1]. The advantage of this procedure compared to that

[1] See Refs. [17, 18, 21, 22] for alternative determinations of γ.

employed in previous works, where the shape was determined from the theoretical calculation itself, is a reduction of both experimental and theoretical uncertainties of the resulting value of $|V_{ub}|$. We have found that the LCSR and FNAL form factors yield values for $|V_{ub}|$ which agree with the UTangles result, but differ, at the 2σ level, from the HFAG value obtained from inclusive decays. The HPQCD form factor, on the other hand, is compatible with both UTangles and the inclusive $|V_{ub}|$. Our results show a certain preference for the UTangles result for $|V_{ub}|$, disfavouring a new-physics scenario in B_d mixing, and highlight the need for a re-analysis of $|V_{ub}|$ from inclusive $b \to u\ell\nu$ deacys.

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References

[1] M. Okamoto *et al.*, Nucl. Phys. Proc. Suppl. **140** (2005) 461 [arXiv:hep-lat/0409116].
[2] E. Dalgic *et al.*, Phys. Rev. D **73** (2006) 074502 [arXiv:hep-lat/0601021].
[3] A. Khodjamirian *et al.*, Phys. Lett. B **410** (1997) 275 [hep-ph/9706303];
E. Bagan, P. Ball and V.M. Braun, Phys. Lett. B **417** (1998) 154 [hep-ph/9709243];
P. Ball, JHEP **9809** (1998) 005 [arXiv:hep-ph/9802394];
A. Khodjamirian *et al.*, Phys. Rev. D **62** (2000) 114002 [hep-ph/0001297];
P. Ball and R. Zwicky, JHEP **0110** (2001) 019 [arXiv:hep-ph/0110115];
P. Ball and E. Kou, JHEP **0304** (2003) 029 [arXiv:hep-ph/0301135];
P. Ball and R. Zwicky, Phys. Rev. D **71** (2005) 014029 [arXiv:hep-ph/0412079];
A. Khodjamirian, T. Mannel and N. Offen, Phys. Rev. D **75**, 054013 (2007) [arXiv:hep-ph/0611193].
[4] P. Ball and R. Zwicky, Phys. Rev. D **71** (2005) 014015 [arXiv:hep-ph/0406232].
[5] B. Aubert *et al.* [BABAR Collaboration], Phys. Rev. D **72** (2005) 051102 [arXiv:hep-ex/0507003].
[6] P. Ball and R. Zwicky, Phys. Lett. B **625** (2005) 225 [arXiv:hep-ph/0507076].
[7] B. Aubert *et al.* [BABAR Collaboration], Phys. Rev. Lett. **98** (2007) 091801 [arXiv:hep-ex/0612020].
[8] P. Ball, Phys. Lett. B **644** (2007) 38 [arXiv:hep-ph/0611108].
[9] D. Becirevic and A. B. Kaidalov, Phys. Lett. B **478** (2000) 417 [arXiv:hep-ph/9904490].
[10] C. Albertus *et al.*, Phys. Rev. D **72** (2005) 033002 [arXiv:hep-ph/0506048];
J. M. Flynn and J. Nieves, Phys. Rev. D **75**, 013008 (2007) [arXiv:hep-ph/0607258]; arXiv:hep-ph/0703284.
[11] C. G. Boyd, B. Grinstein and R. F. Lebed, Phys. Rev. Lett. **74** (1995) 4603 [arXiv:hep-ph/9412324];
C. G. Boyd and M. J. Savage, Phys. Rev. D **56** (1997) 303 [arXiv:hep-ph/9702300].
[12] H. F. A. Group, arXiv:0704.3575 [hep-ex].
[13] P. Ball, J. M. Frere and J. Matias, Nucl. Phys. B **572** (2000) 3 [arXiv:hep-ph/9910211].
[14] J. R. Andersen and E. Gardi, JHEP **0601** (2006) 097 [arXiv:hep-ph/0509360].
[15] S. W. Bosch, B. O. Lange, M. Neubert and G. Paz, Nucl. Phys. B **699** (2004) 335 [arXiv:hep-ph/0402094];
B. O. Lange, M. Neubert and G. Paz, Phys. Rev. D **72** (2005) 073006 [arXiv:hep-ph/0504071].
[16] M. Neubert, talk at this conference.
[17] M. Bona *et al.* [UTfit Collaboration], arXiv:hep-ph/0606167; updated results available at `http://www.utfit.org/`.
[18] J. Charles *et al.* [CKMfitter group], Eur. Phys. J. C **41** (2005) 1 [arXiv:hep-ph/0406184]; updated results and plots available at `http://ckmfitter.in2p3.fr`.
[19] A. Jantsch and H. Lacker, private communication
[20] A. Poluektov *et al.* [Belle Collaboration], Phys. Rev. D **73** (2006) 112009 [arXiv:hep-ex/0604054].
[21] P. Ball and R. Zwicky, JHEP **0604** (2006) 046 [arXiv:hep-ph/0603232];
P. Ball, G. W. Jones and R. Zwicky, Phys. Rev. D **75** (2007) 054004 [arXiv:hep-ph/0612081].
[22] R. Fleischer, arXiv:0705.1121 [hep-ph].
[23] A.J. Buras, R. Fleischer, S. Recksiegel and F. Schwab, Eur. Phys. J. **C45** (2006) 701 [arXiv:hep-ph/0512032];
M. Bona *et al.* [UTfit Collaboration], JHEP **0603** (2006) 080 [arXiv:hep-ph/0509219];
M. Blanke, A. J. Buras, D. Guadagnoli and C. Tarantino, JHEP **0610** (2006) 003 [arXiv:hep-ph/0604057];
P. Ball and R. Fleischer, Eur. Phys. J. C **48** (2006) 413 [arXiv:hep-ph/0604249].